NATURAL RESOURCES CONSERVATION SERVICE
CONSERVATION PRACTICE STANDARD

IRRIGATION WATER CONVEYANCE (FT)

Steel Pipeline

CODE 430FF

DEFINITION

A pipeline and appurtenances installed in an irrigation system.

SCOPE

This standard applies to the design and installation of buried steel irrigation pipelines and steel irrigation pipelines permanently installed above ground. If soil conditions do not permit below ground installation, on ground installation is restricted to pipelines not greater than 6 in. in diameter. Pipelines greater than 6 in. installed under those conditions shall be placed on aboveground supports. This standard is restricted to pipelines not greater than 48 in. in diameter and does not apply to short pipes used in structures such as siphons, outlets from canals, and culverts under roadways.

PURPOSE

To prevent erosion of loss of water quality or damage to land, to make possible the proper management of irrigation water, and to reduce water conveyance losses.

CONDITIONS WHERE PRACTICE APPLIES

The pipeline shall be planned and located to serve as an integral part of an irrigation water distribution or conveyance system that has been designed to facilitate the conservation use of soil and water resources on a farm or group of farms.

All areas served by the pipeline shall be suitable for use as irrigated land.

Water supplies and irrigation deliveries to the area shall be sufficient to make irrigation practical for the crops to be grown and the irrigation water application methods to be used.

DESIGN CRITERIA

Working pressure. The pipeline shall be designed to meet all service requirements without the use of a working pressure that will produce tensile stresses in the pipe greater than a design stress equal to 50 percent of yield-point stress. Design stresses for commonly used steel and steel pipe classes are shown in column two below:

Specification and grade of steel	Design stress 50 pct yield point
ASTM-A-283	*lb/in.*^{2}
Grade B	13,500
Grade C	15,000
Grade D	16,500
ASTM-A-570	
Grade A	12,500
Grade B	15,000
Grade C	16,500
Grade D	20,000
Grade E	21,000
AWWA-C-200	
Furnace butt weld	12,500
Grade A	15,000
Grade B	17,500
Grade X42	21,000

In computing tensile stresses in steel pipe, the following items must be considered:

1. The pressure to be delivered at the end of the pipeline
2. The friction head loss
3. The elevation differential between the outlet and the inlet of the pipe, and
4. Any pressure due to water hammer or surge that may be created by the closure of a valve in the pipeline.

Flow capacity. The design capacity shall be based on whichever of the following is greater:

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1. Capacity to deliver sufficient water to meet the weighted peak consumptive use rate of the crops to be grown, or
2. Capacity sufficient to provide an adequate irrigation stream for the methods of irrigation to be used.

Minimum wall thickness. Minimum pipe wall thickness shall be as follows:

Nominal diameter	Wall thickness
in.	
4 - 12	14 gage less 12.5 %
14 - 18	12 gage less 12.5 %
20 - 24	10 gage less 12.5 %
26 - 36	3/16 in. less 12.5 %
38 - 48	1/4 in. less 12.5 %

Friction loss. For design purposes, the pipeline friction loss shall be based on that computed with Manning's Formula with n equal to no less than 0.012 for unlined and no less than 0.010 for lined pipe.

Check, pressure-relief, vacuum-release, and air-release valves. If detrimental backflow may occur, a check valve shall be installed between the pump discharge and the pipeline.

A pressure-relief valve shall be installed at the pump location if excessive pressure can build up when all valves are closed. Also, in closed systems where the line in protected from reversal of flow by a check valve and excessive surge pressure can build up, a surge chamber or a pressure-relief valve shall be installed close to the check valve on the side from the pump.

Pressure-relief valves shall be no smaller than ¼ in. nominal size for each diameter inch of the pipeline and shall be set at a maximum of 5 $lb/in.^2$ above the safe working pressure of the pipeline. A pressure-relief valve or surge chamber shall be installed at the end of the pipeline if needed to relieve surge.

Air-release and vacuum-release valves or combination air-release and vacuum-release valves shall be placed at all summits in the pipeline, at the end of the line, and between the pump and check valve if needed to provide a positive means of air entrance or escape.

Air-release and vacuum-release valve outlets shall be at least ½ in. in nominal diameter when specified for lines 4 in. or less in diameter, at least 1 in. outlets for lines 5 to 8 in. diameter, at least 2 in. outlets for lines 10 to 16 in. diameter, at least 4 in. outlets for lines 18 to 28 in. in diameter, at least 6 in. outlets for lines 30 to 36 in. in diameter, and at least 8 in. outlets for lines 38 to 48 in. in diameter.

For pipelines larger than 16 in. in diameter, 2 in. air-release valves may be used in place of the sizes indicated if they are supplemented with vacuum-release valves that provide a vacuum-release capacity equal to the sizes shown.

Drainage and flushing. Provisions shall be made for completely draining the pipeline if a hazard is imposed by freezing temperatures or if drainage is specified for the job.

If provisions for drainage are required, drainage outlets shall be located at all low places in the line. These outlets may drain into dry wells or to points of lower elevation. If drainage cannot be provided by gravity, provisions shall be made to empty the line by pumping.

Outlets. Appurtenances for delivering water from a pipe system to the land, to a ditch, or to a surface pipe system shall be known, as outlets. Outlets shall have capacity to deliver the required flow:

1. To a point at least 6 in. above the field surface,
2. To the hydraulic gradeline of a pipe or ditch,
3. To an individual sprinkler, lateral line, or other sprinkler line at the design operating pressure of the sprinkler or line.

Pipe supports. Irrigation pipelines placed above ground shall be supported by suitably built concrete, steel, or timber saddles shaped to support the pipe throughout the arc of contact, which shall be not less than 90 degrees nor more than 120 degrees as measured at the central angle of the pipe. If needed to prevent overstressing, ring girder-type supports shall be used. Support spacing shall insure that neither the maximum beam stresses in the pipe span or the maximum stress at the saddle exceed the design stress values.

Thrust control. For aboveground pipelines with welded joints, anchor blocks and expansion joints shall installed at spacings that limit pipe movement due to expansion or contraction to a maximum of 40 percent of the sleeve length of the expansion coupling to be used. The maximum length of pipeline without expansion joints shall be 500 ft. Aboveground pipelines with rubber gasket-type joints shall have the movement of each pipe length restrained by

steel holddown straps at the pipe supports or by anchor blocks instead of normal pipe supports. Anchor blocks usually are not required on buried pipelines. Expansion joints shall be installed, as needed, to limit stresses in the pipeline to the design values.

Thrust blocks shall be required on both buried and aboveground pipelines at all points of abrupt changes in grade, horizontal alinement, or reduction in size. The blocks must be of sufficient size to withstand the forces tending to move the pipe, including those of momentum and pressure, as well as forces due to expansion and contraction.

Joints and connections. All connections shall be designed and constructed to withstand the working pressure of the line without leakage and to leave the inside of the pipeline free of any obstruction that would reduce the line capacity below design requirements. On sloping lines, expansion joints shall be placed adjacent to and downhill from anchors or thrust blocks. If cathodic protection is required, high resistance joints shall be bridged to insure continuous flow of current.

A dielectric connection shall be placed between the pump and the pipeline and between pipes with different coatings.

Corrosion protection. Interior protective coatings shall be provided if the pH of the water to be conveyed is 6.5 or lower. Cement mortar coatings may be used if the water to be conveyed has a pH of 5.5 or higher and a sulfate content of 150 p/min or less.

All pipe exteriors for underground lines must be fully protected against corrosion. To meet protection requirements, all pipe must be coated and must be provided with supplementary cathodic protection as specified in item 2 below:

1. A Class A protection coating shall be provided if the soil-resistivity survey shows that either (a) 20 percent or more of the total surface area of the pipeline will be in soil having a resistivity of 1,500 ohm-cm or less or (b) 10 percent or more of the total surface area of the pipeline will be in soil having a resistivity of 750 ohm-cm or less. A Class B coating shall be provided for pipe to be installed in soil having a resistivity greater than 1,500 ohm-cm.

2. Supplementary cathodic protection shall be provided if the soil-resistivity survey shows that any part of the pipeline will be in soil whose resistivity is less than 10,000 ohm-cm unless galvanized pipe is used. Pipe to soil potential shall be not less than 0.85 V negative, referred to as a copper/copper-sulfate reference electrode, with the cathodic protection installed. The initial anode installation shall be sufficient to provide protection for a minimum of 15 years.

Cathodic protection shall be provided for galvanized pipe if the soil-resistivity survey shows that any part of the galvanized pipe will be in soil whose resistivity is less than 4,000 ohm-cm. Galvanized pipe requiring cathodic protection shall have a Class B coating.

The total current required, the kind and number of anodes needed, and the expected life of the protection may be estimated as shown below:

The total cathode current required may be estimated from the formula.

$$I_t = C\left[\frac{A_i}{Re_1} + \frac{A_2}{Re_2} + . \frac{A_n}{R_{en}}\right]$$

Where:

I_t = total current requirement in mA
A = surface area pipe in ft^2
R_e = soil resistivity in ohm-cm
C = a constant for a given pipe coating

For design purposes, this constant shall be considered to be not less than 32 for Class A coatings and not less than 60 for class B coatings.

The kind of galvanic anode to be used depends on the resistivity of the soils in the anode bed location. If the resistivity of the anode bed is:

a. Less than 2,000 ohm-cm, zinc anodes shall be used;

b. Between 2,000 and 3,000 ohm-cm, either zinc or magnesium anodes shall be used; and

c. Between 3,000 and 10,000 ohm-cm, magnesium anodes shall be used.

Anodes shall not be required on pipelines if soil resistivity is greater than 10,000 ohm-cm.

The number of anodes needed to protect the pipeline may be estimated by dividing the total cathode current requirement of the pipeline by the current output per anode.

Thus:

$$N = I_t / I_m \text{ and } I_m = k / R$$

Where:

N = number of anodes needed
I_t = total current requirement in mA
I_m = maximum anode current output in mA
k = constant for a given anode
R = soil resistivity of the anode bed in ohm-cm.

The expected life of an anode, based on the use of 17 lb/ampere year for magnesium and 26 lb/ampere year for zinc and a utilization factor of 0.80, shall be computed as follows:

Magnesium . . . . . $Y = 47W / I_o$

Zinc . . . . . $Y = 31W / I_o$

Where:

Y = expected life in years

W = weight of anode in lb

I_o = design anode current in mA = I_m unless resistors are used in anode circuit to reduce output

If resistors are used to reduce anode current output to increase service life, the number of anodes required shall be based on the regulated output of the anode rather than on the maximum output, I_m.

3. Preliminary soil-resistivity measurements to determine coating requirements and the approximate amount of cathodic protection needed may be made before the trench is excavated. For this purpose, field resistivity measurements shall be made, or samples for laboratory analysis shall be taken at least every 400 ft. long the proposed pipeline and at points where there is a visible change in soil characteristics. If a reading differs markedly from a preceding one, additional measurements shall be taken to locate the point of change. Resistivity determinations shall be made at two or more depths in the soil profile at each sampling station; the lowest depth shall be the strata in which the pipe will be laid. The lowest value of soil resistivity found at each sampling station shall be used as the design value for that station.

After the pipe trench is excavated, a detailed soil-resistivity survey shall be made as a basis for final design of the coating and the required cathodic protection. At this time, resistivity measurements shall be made in each exposed soil horizon at intervals not exceeding 200 ft. The lowest value of soil resistivity found at each sampling station shall be used as the design value for that station. If design values for adjacent stations differ significantly, additional intermediate measurements shall be made.

Steel pipelines placed on the ground shall be limited to sites where the soil resistivity along any part of the pipeline is greater than 4,000 ohm-cm. Pipe at anchor or thrust blocks shall be embedded or attached rigidly with a holddown strap.

All pipe installed above ground shall be galvanized or shall be protected with a suitable protective paint coating, including a primer coat and two or more final coating.

Materials. All materials shall meet or exceed the minimum requirements of this standard.

Plans and specifications

Plans and specifications for steel irrigation pipelines shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purposes.

Irrigation Water Conveyance

Steel Pipeline Specifications

Installation

Buried pipelines. Pipe shall be laid to the lines and grades as shown on the drawings and/or as staked in the field and shall be placed deep enough below the land surface to protect it from the hazards imposed by traffic crossings, farm operations, freezing temperatures, or soil cracking. The cover shall be a minimum of 2 ft, but in soils susceptible to deep cracking, the cover shall be a minimum of 3 ft. If necessary to install the pipe at a lesser depth, adequate protection shall be provided by placing extra fill over the pipeline, constructing a fence or other surface barriers, or using extra heavy gage pipe.

If trenches are excavated in soils containing rock or other hard material that might damage the pipe or coating material, the trenches shall be excavated slightly deeper than required and then filled to grade with sand or fine earth.

Coated pipe shall be handled in a manner to prevent abrasion of the coating during transportation, placement, and backfilling. Pipe shall not be dropped from cars or trucks or allowed to roll down skids without proper restraining ropes. Each section of pipe shall be delivered in the field as near as practicable to the place where it is to be installed. When stockpiled, it shall be neatly piled and blocked with strips between tiers. If the pipe must be moved longitudinally along the trench, care shall be taken to insure that the pipe and the coating are not damaged. Pipe shall not be rolled or dragged on the ground. If the pipe is supported, as for welding, supports shall be of sufficient width and number and be padded, if necessary, to prevent damage to the coating.

Joints and connections. Special field joints shall be installed according to the manufacturer's recommendations. On buried pipelines, high-resistance joints between pipe lengths shall be electrically bridged with a welded, brazed, or soldered copper wire not smaller than 4/0 gage in size. If coated pipe is field welded, special care shall be taken to avoid burning the protective coating. After the joints are welded, they shall be covered with a coating equal in quality to that specified for the pipe. Dielectric connections shall be placed as specified on the drawings.

Aboveground pipelines. Concrete, timber or other pipe supports, and anchor and thrust blocks shall be constructed at the locations to the dimensions shown on the drawings and/or as staked in the field. Saddles shall be shaped to firmly support the pipe throughout the full arc of contact. At least two layers of felt strips shall be placed between the pipe and its support. The felt shall cover the entire area of contact between the pipe and the saddle. A graphite lubricant shall be placed between the felt strips before the pipe is placed in the saddle.

Onground pipelines. Pipe shall be laid to the lines and grades shown on the drawings and/or as staked in the field and shall be placed so that it is protected from the hazards imposed by traffic crossings, farm operations, or other hazards. The ground shall be shaped so as to provide support needed. If there are rocks or objects that might damage the pipe coating, sand or soil shall be used as a base for the pipe.

Concrete, timber, or other anchors and thrust blocks shall be constructed at the locations to the dimensions shown on the drawings or as staked in the field, or both.

Paint. Unless otherwise specified, all above ground pipelines and on ground pipelines shall be painted as follows:

1. All grease and oil shall be removed from the pipe surface by steam cleaning or by solvent cleaning. All dirt, surface rust, and loose scale shall be removed by wire brushing, flame cleaning, use of rotary abrading tools, or light sand blasting.
2. To the cleaned pipe there shall be applied one priming coat of red lead base paint conforming to the requirements of Federal Specification TT-P-86e, Types 1, 11, or III, or one priming coat of synthetic primer conforming to the requirements of Federal Specification TT-P-636c(l).
3. The painting shall be completed by applying two coats of aluminum paint. The aluminum paint shall be prepared by mixing aluminum paste conforming to Federal Specification TT-P-320b(1), Type 11, Class B with mixing varnish conforming to the requirements of Federal Specification TT-V-81d, Type 11, Class B at the rate of 2 pounds of aluminum paste per gallon of varnish. The paint shall be mixed at the time of use.

Coating. Coating material and application procedures shall be as detailed in the specifications indicated under "Materials" by class of coating.

Cathodic protection. Buried steel pipelines shall be protected with sacrificial galvanic anodes if they are specified to supplement the protection provided by the pipe coating. The anodes shall be of the kind and number specified for the job or as shown on the drawings, or both. Anode materials shall be as specified under "Materials."

Anodes shall be placed as shown on the drawings. If horizontally placed, anodes shall be at or below the bottom elevation of the pipeline. Vertically placed anodes shall have a minimum distance to 3 ft between the ground surface and the top of the anode. Anodes shall not be placed in fill areas, and magnesium anodes must be placed a minimum distance of 10 ft from the pipeline.

Anodes shall be bedded in moist fine clay, clay loam, silt, or silt loam. In sandy and gravelly areas, fine material must be imported for bedding and for covering the anodes to a depth of 6 in. The packaged anodes and the fine textured soil used for bedding and backfill shall be thoroughly wetted.

The lead wire from the anode, or the header wire for multiple anode installations, shall be attached to the pipeline by cadwelding, thermowelding, or other similar processes. The area of damaged pipe coating and the weld shall then be covered with a coating equal in quality to that of the specified original pipe coating.

Testing station facilities shall be located and installed as specified for the job or as shown on the drawings, or both. Wires at testing stations shall be attached to the pipe by one of the processes specified for anode lead wires.

Testing. Underground steel pipelines shall be tested before placing the backfill over the field joints. Aboveground steel pipelines may be tested at any time after they are ready for operation.

The pipeline shall be filled with water, taking care to bleed air and prevent water hammer. When the line is full, all valves shall be closed, and the line shall be brought up to full design working pressure. All joints shall then be carefully inspected for leakage, and any visible leaks shall be repaired.

It shall be demonstrated by testing that all valves, vents, surge chambers, and other appurtenances function properly when the pipeline is operated at design capacity. Objectionable surge, water hammer, unsteady delivery of water, damage to the pipeline, and detrimental discharge from control valves are evidence of malfunction.

Materials

Appurtenances. Standard fittings shall be used for the pipe. Elbows, tees, crosses, reducers, gate valves, check valves, air-and-vacuum-release valves, pressure-relief valves, and pressure regulators shall be of the size and material specified or as shown on the drawings. Steel supports and saddles shall be constructed of material that equals or exceeds the requirements specified in ASTM-A-36, "Structural Steel."

Pipe. Pipe shall equal or exceed the requirements specified in the following: American Water Works Association Designation C-200, "Steel Water Pipe 6 Inches and Larger"; ASTM-A-53, “Pipe, Steel, Black and Hot-Dipped, Zinc-Coated (Galvanized) Welded and Seamless for Ordinary Uses"; or ASTM-A-211, "Spiral-Welded Steel or Iron Pipe."

Interior coating. If an interior coating is specified, the coating shall meet the requirements of one of the following:

1. The interior of the pipe shall be coated with a coal-tar primer followed by a hot coat of coal-tar enamel applied either manually or mechanically. All material and applications shall be in accordance with the requirements in American Water Works Association Specification C-203 pertaining to interior coatings.
2. Materials and workmanship shall be equal to those indicated in American Water Works Association Specification C-205.
3. Epoxy resin interior coatings shall meet the requirements given in this standard under the specifications for epoxy resin exterior coatings.

Exterior coatings. Exterior coatings shall be Class A, Class B, or paint specified for the job.

If a Class A coating is required, the coating shall meet the requirements of one of the following:

1. The outside of the pipe shall be coated with a coal-tar primer followed by a hot coat of coal-tar enamel into which shall be bonded an asbestos felt wrapper and finished with a kraft paper or one coat of water-resistant whitewash. All materials and applications shall be in accordance with American Water Works Association Specification C-203.
2. Epoxy resin coatings shall have physical characteristics and be applied as follows:
   a. The pipe shall be cleaned of all contaminants such as lacquer, wax, coal-tar, asphalt, oil, or grease.
   b. The pipe shall be shot blasted to white metal according to steel structure Painting Council Specification SSPC-SP5-63, using S-170 shot or equivalent.
   c. After the pipe is blasted, the pipe surface shall be power wire brushed.
   d. The coating shall be applied to the clean preheated (450 to 475 degrees F) pipe, using best commercial practice, to a minimum thickness of 7 mils. The thickness shall be determined by using a magnetic thickness gage. The heat source shall not leave residue on the pipe surface.
   e. The coated pipe shall be maintained at or above 425 degrees F for a minimum of 20 seconds for full cure. At the end of this time, the pipe shall be water quenched before a support roller comes in contact with the coated surface.
   f. All epoxy resin coated pipe shall be electrically inspected for holidays by using a wet electrode to apply 1,000 V, direct current, across the coating. All imperfections shall be repaired.
   g. The epoxy resin coating shall meet the physical requirements of Class A cured epoxy resin coating indicated in table 1.

Table 1-Requirements for epoxy coating

Test description	Procedure	Unit	Minimum test value
Impact	ASTM-G-14	in.-lb	120
Hardness	ASTM-D-2583	------	10
Adhesion	ASTM-D-1002	lb/in.[2]	4,500
Disbonding cathodic	ASTM-G-8 (Method A)	------	([1])
Chemical resistance	ASTM-G-20	------	No visual effect
Thermalshock	320° F (160° C) to -80° F (-62° C) 4 in. by 4 in. coated panel[2]	10 cycles	No visual effect

[1] No film failure (hydrogen gas at cathode or corrosion products of iron at anode) during first hour of testing. After 30 days. the maximum allowable equivaler circle diameter of the unsealed area must be 25.4 mm.
[2] Test at 320° F for 30 min, then remove panel and immediately test at –80° F for 15 min. The relative humidity of the laboratory room must be 50 percent when the sample is exposed.

If a Class B coating is required, the coating shall meet the requirements of one of the following:

1. The outside of the pipe shall be coated with coal-tar primer followed by a hot coat of coal-tar enamel and finished with a kraft paper or one coat of water-resistant whitewash. All materials and applications shall be according to American Water Works Association Specification C-203, except that the asbestos felt wrapper may be omitted.
2. The outside of the pipe shall be coated with a coal-tar primer followed by a hot coat of coal-tar enamel into which shall be bonded an asbestos felt wrapper and finished with a kraft paper or one coat of water-resistant whitewash. All materials and applications shall meet the requirements in American Water Works Association Specification C-203, except that the minimum thickness of hot coal-tar enamel applied by pouring and spreading may be 1/32 in.
3. All materials and workmanship shall meet the requirements in Federal Specification HHT-30a, August 2, 1967, Tape, Pipe Coating, Coal-Tar, Hot Applied, and Primer.
4. The plastic tape coating shall be capable of withstanding the moisture and soil

conditions to which it is to be subjected. All material shall be according to American Water Works Association Specification C-209 or to Interim Federal Specification L-T-001512 for Type I standard thickness tape, except that the tape coating may be of either rubber material or the specified plastic materials. Application shall be as follows:

a. The surface of the pipe to be coated shall be cleansed of all foreign materials, such as oil, grease, dirt, mud. Any knurls, burrs, or other sharp points shall be removed by filing, peening, or wire brushing.

b. The continuity of the applied plastic coating shall be of a quality that insures that all pipe, joints, and fittings can pass an inspection test conducted with a spark discharge holiday detector at 1,500 V.

Paint. Paint shall meet the Federal specifications detailed under "Installation."

Anodes. Zinc anodes must meet or exceed the requirements specified in ASTM-B-418, "Cast and Wrought Galvanic Zinc Anodes for use in Saline Electrolytes."

Each anode shall have a full length core with a single strand of insulated copper wire solidly attached to it. The wire shall be No. 12 or larger. If a header wire is used, the gage must be adequate to carry the design current with no more than a 20-mV I-R drop.

All anodes shall be commercially packaged. The packaged backfill mix shall be of the following proportions by weight.

Zinc- 20 to 30 pct bentonite; 70 to 80 pct gypsum
Magnesium- 20 to 25 pct bentonite; 70 to 75 pct gypsum; 5 pct sodium sulfate

PLANNING CONSIDERATIONS FOR WATER QUANTITY AND QUALITY

Quantity

1. Effects on the water budget, especially on infiltration and evaporation.
2. Effects on downstream flows or aquifers that would affect other water uses or users.
3. Potential use for irrigation water management.
4. Effects of installing a pipeline on vegetation that may have been located next to the original conveyance.

Quality

1. Effects of installing the pipeline (replacing other types of conveyances) on channel erosion or the movement of sediment and soluble and sediment-attached substances carried by water.
2. Effects on the movement of dissolved substances into the soil and on percolation below the root zone or to ground water recharge.
3. Effects of controlled water delivery on the temperatures of water resources that could cause undesirable effects on aquatic and wildlife communities.
4. Effects on wetlands or water-related wildlife habitats.
5. Effects on the visual quality of water resources.